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Hydroinformatics in the service of the qualities

Hydrolink

HYDROINFORMATICS IN THE SERVICE OF THE QUALITIES

BY ZORAN VOJINOVIC AND MICHAEL B. ABBOTT

Our knowledge and understanding of the nature and behaviour of water, and all that water maintains and destroys, has undergone a significant transmutation over the last few years (e.g. Vojinovic and Abbott, 2012). The subject of 'urban flooding' provides illustrative examples of how our ways of thinking have changed.

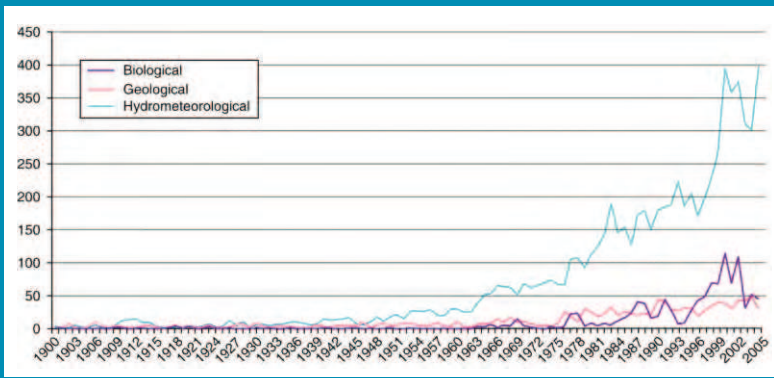

Figure 1: Trends of 'natural disasters' (Source: International Disaster Database EM-DAT, University of Louvain, Belgium)

Some of the early efforts in dealing with floods and flood-related disasters were only concerned with the construction of structures (e.g., levees, floodwalls, dams, embankments, storage basins, diversions, etc.) without significant consideration of aspects which are nowadays regarded as equally important, if not more important. Inspired by the realisation that flood risk can hardly ever be completely eliminated; the traditional 'flood defence' culture has been replaced with the culture of learning how to live under flood risk and how to better respond to it. However, despite the fact that our thinking has changed significantly over time and even though our technological capabilities for dealing with floods have advanced rapidly, the records show that floods still have the fastest rate of increase in relation to other types of disasters: see Figure 1. Devastation due to these events occurs almost daily. This paradoxical situation proves that our earlier ways of thinking are inadequate and that we must undergo a major shift in this very way of thinking and its corresponding values and practices.

From the Mechanistic to a Holistic Worldview

Despite our deep respect for modern science, most of the current research and practical efforts appear to be the same as those that have become so characteristic of modern science generally, namely those of ordering, numbering, counting and computing. Modern science has set humanity on a path to address many of its problems, where dealing with floods is just one example, by using its logics, its disciplines, its technologies and its observations, while ignoring the world of qualities as means for uncovering the reality of the phenomena. Such qualities as feelings, emotions, ethical sensibility, consciousness and spirit are absent from modern science and its scope has been restricted to the study of phenomena that can be measured and quantified. Furthermore, the modern scientific paradigm is based on the premise that in every complex system (or phenomenon) the behaviour of the whole can be understood entirely from the properties of its parts, which is a mechanistic or reductionist way of thinking. This kind of thinking has influenced our narrowly-focused academic disciplines which can only represent different parts of the 'reality' that we experience. Undoubtedly, this thinking has on the one hand provided great benefits, but on the other hand it has also brought many side-effects. Today, we can observe great technological discoveries on one side but on the other side we are witnessing our inabilities to deal with economic crises, inflation, poverty, energy shortage, pollution, natural disasters and so on – and on. The predominance of almost exclusively *techno-centric* and *piecemeal* approaches which put the *economic prosperity* and *growth* as first (or most dominant) values to be preserved, above social, cultural and ecological well-being, has led to the development of less sustainable and less efficient means of responding to any kind of crisis.

It is now becoming obvious that the present way of thinking has created a profound cultural imbalance in our way of looking at life and as such it lies at the very root of many of our crises including the crisis in our search for sustainable living, where dealing with floods is just one part. In view of the limitations of modern science, and consequently of the present-day ideologies, which have nowadays become so evident, we have to undergo a new paradigm shift in our thinking and our practice. We have to undergo a shift towards a holistic paradigm which can change our perception from a disciplinary and defensive one into a trans-disciplinary and progressive (and indeed transcendental) one that turns challenges into possibilities for a change that can re-shape our future.

The Rise of Holistic Thinking

As introduced in Vojinovic and Abbott (2012), the prevailing modern scientific way of thinking that dates from the *Condemnations in Paris of March, 1277* – has been an analytical (i.e., a mechanistic or reductionist) way of thinking. This way of thinking is still successful in many cases, but it does have the effect of shifting the focus away from the phenomenon itself, which then only takes the second place. As opposed to the analytical way of thinking there is a holistic way of thinking which is based on the premise that the properties of the parts are not intrinsic properties of the whole and that they can be understood only within the context of the larger whole. Such a way of thinking emerged through different disciplines and movements, and these are the subjects of phenomenology (e.g., Brentano, Meinong, Husserl, Heidegger, Max Scheler, Merleau-Ponty, Sartre and others), Gestalt psychology (e.g., Ehrenfels, Koffka, Wertheimer and Köhler), organismic biology (e.g., Harrison, Henderson, Woodger and others), romantic movement in art, literature and philosophy (e.g., Goethe, Blake, Kant), ecology (e.g., Haeckel, von Uexküll, Lovelock, Patten and others), general system theory (e.g., von Bertalanffy), cybernetics (e.g., Wiener, Forrester), quantum physics (e.g., Planck, Heisenberg, Bohm and others), Category Theory (e.g., Freyd and Scedrov) and so on. Henri Bortoft has so brilliantly summarised the words of some of these great thinkers (see Bortoft, 2013).

As mentioned above, holistic thinking has been expressed repeatedly, in one way or another. However, mathematical models of complexity and multiple relationships gained interest only recently with the advances in computational power which allowed us to model the nonlinear processes associated with interconnectedness and interactions. Consequently, several mathematical concepts and theories have emerged. Such examples are: category theory, complex adaptive systems theory (complexity theory), multi-agent system theory (agent-based models), evolving automata, game theory, nonlinear dynamics theory, chaos theory and fractal geometry, computational sociology, autopoietic network theory, and so on.

A holistic way of thinking and working draws from the understandings brought by *phenomenology* and *complexity theory,* where individual elements co-evolve together, both in development and application, Figure 2. To place this in the context of flooding, phenomenology shifts the focus from the traditional way of thinking about flooding as that which appears (which resembles the final result) into the thinking of flooding as the experience of the *appearing* of what appears (which is a holistic, or dynamic, way of thinking, i.e., thinking in terms of complexities, relations and interactions between the root causes that can lead to flooding as a collection of phenomena, in the exact Husserlian sense, Husserl, 1900, 1901/1913). This way of working aims for a more profound engagement of those affected (i.e., stakeholders) who are seeking multipurpose (or multifunctional) solutions which are not only technologically and economically efficient, but which are also ecologically sustainable and socially just (Vojinovic, 2014). This way of thinking and working is now the way forward for hydroinformatics.

From a Hydroinformatics of the Quantities to a Hydroinformatics of the Qualities

Hydroinformatics was born when numerical modelling and data collection and processing came into a synergic relation at the end of the 1980s (Abbott, 1991). By that time the field of numerical modelling had expanded its range from one that was restricted to the modelling of flows of water exclusively to a much wider-ranging field that combined flows and all that these flows transported with them, which increasingly included living creatures that had, in turn, their own means of locomotion (Abbott, 2002). With the extension of hydroinformatics onto the sociotechnical dimension, the role of hydroinformatics has turned into a *transmutation* of the corresponding social environment from a reactive one into an interactive one. Although we have been traditionally concerned for the most part with a *hydroinformatics of the quantities*, where the qualitative dimension has largely been overlooked, the focus now, and increasingly, has to be shifted towards a *hydroinformatics of the qualities*. It is then important to emphasise here that hydroinformatics is no longer only about numbers, even as it continues to be based to a large extent upon the use of numbers, but it is also about such qualities as perceptions, experi-

Figure 2: Formation and propagation of risk is the result from the coevolutionary nonlinear process between the ever changing social, technical and natural processes. Dots represent sub-processes and activities and lines represent their interactions (Source: Vojinovic 2014)

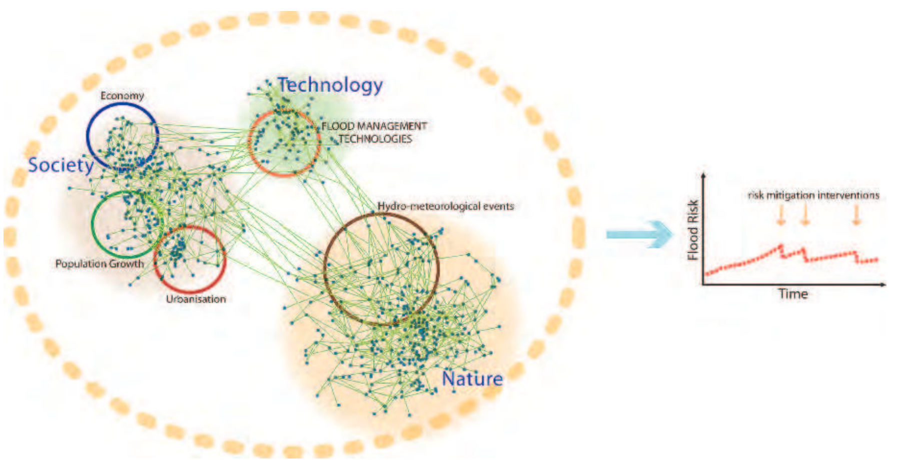

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Figure 3: Flooding in the Historic City of Ayutthaya, Thailand (November 2011 - Photo: Z. Vojinovic). The Ayutthaya heritage monuments have an immense intrinsic cultural significance which cannot possibly be expressed in monetary terms

ences and emotions, including some of the deepest emotions of mankind and, if only through surrogation, of so many other creatures in the world of nature besides. Thus, even as we may want to compute the movements of populations under flood conditions using traditional methods of modelling, we now move into the world of qualities when describing states of being in these populations.

This brings the importance of *hydroinformatics environments* which use dynamic, highly-detailed and relevant illustrations, almost always in colour, of the objects that are of the greatest concern to the individual participants and to the society as a whole, who are then represented by their active stakeholders (Vojinovic and Abbott, 2012). The value of the psychic means of personalised perception as opposed to the modern-scientific means of impersonal perception lies in this direction, whereby the perception of a colour enhances the impact of an emotionally charged 'surreal' object and is no longer associated with an emotionally neutral 'real' object. Thus, when the user interface projects the streets along which the various families' children are walking to school, the blobs that represent the children may be simply 'children-coloured' when there is no danger from flooding, with the families correspondingly indifferent to any flood-related danger, but may appear flashing with an intensified 'children-colour' when these children are in danger and the parents may need to intercede. We may call this "thinking in terms of situations" and in this example it is realised by bringing the danger into coincidence with the potential victims in the minds of their parents, thereby contextualising their deepest concerns, whether to assuage them or to support them. We have to do here with an emotional impact which is entirely qualitative, even as it depends upon the quantitative resources of technology.

The above discussion implies that the traditional risk quantification process, which has been dominating the 'flood management practice' for some time must now be combined with qualitative considerations. The current decision-making practice has advanced in many areas but it is still dominated by the traditional cost-benefit type of analysis (i.e., CBA analysis). As discussed at some length in Vojinovic and Abbott (2012), this approach may appear appealing but it is very much a simplistic way of assessing the benefits of different measures (including flood protection standards and potential damages) even as *the qualities*, such as ethical, cultural, historical and ecological values are almost completely left unattended.

As the holistic way of working aims for a more profound engagement of stakeholders who are seeking for multipurpose (or multifunctional) solutions, our search for such solutions also brings the opportunity to question our current values which are often at the root cause of deeper social inequalities and our unsustainable relationships within the society and with the nature. Hence, the search for multipurpose solutions can be seen as a purpose of a larger whole that consists of a variety of purposeful (i.e., teleological) sectoral activities (i.e., activities of 'smaller' wholes) that all contribute towards the larger purpose (Vojinovic 2014).

To illustrate the holistic way of searching for multipurpose (or multifunctional) solutions we can consider for a moment problems associated with climate extremes that are nowadays causing extreme rainfall and flooding on one side and drought and heat waves on the other. In response to threats from droughts, some cities in the coastal zone have embarked on building desalination plants as a measure to mitigate shortage of drinking water. Looking from a wider perspective, this measure is only shifting our dependency from rainfall (which is needed to fill in our reservoirs and dams) to dependency on energy (which is needed to operate such plants) and does not seem to be sustainable on the long run. At the same time, we are not sufficiently harvesting our other sources of water which can be used to preserve our drinking water reserves. Storing rainwater on sites which have multifunctional purposes can bring greater efficiency of land use. Also, since the availability of space is scarce in urban areas, we can also consider how to utilise the actual water surface in a multifunctional way. A good example of multifunctional use of the water surface is the construction of floating buildings. Furthermore, to deal with the challenge of energy scarcity and to minimise the ecological footprint it is important to develop solutions that can utilise internal sources of water, energy and nutrients first before we go on extracting resources from other areas. Urban wastewater contains high amounts of phosphate and nitrates which could be used as fertiliser for urban agriculture and development of productive landscapes. It can be also used as a source of heat and for biogas production. Productive landscapes can have multiple functions as they can serve not only for amenity and recreational purposes but also to keep our urban sites fresh and cool during heat waves as well as for urban farming. This can be then placed into the context of water - energy - food security. Furthermore, the same holistic thinking would also aim to seek for those multi-purpose solutions that can also promote job creation and reduction in antisocial behaviour and *injustice* (Vojinovic 2014).

Overall, the way forward can be found only if we broaden our view and learn how the natural or social phenomena can provoke a response in a society, or a social group, which in turn can trigger the technical developments, and so on, again and again, in what becomes a network of interactions and relationships through positive feedback (or coevolving) cycles. This recognition opens a new way of analysis which goes beyond the direct objects or actors of concern (development of policies, development of technology for flood mitigation and design of adaptive systems for example), and into the relationships between them. Hence, our planning for more effective resilience requires not only sound engineering knowledge but also a much deeper understanding of *the qualities*, which in turn necessitates a new way of thinking and working within *hydroinformatics*.

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